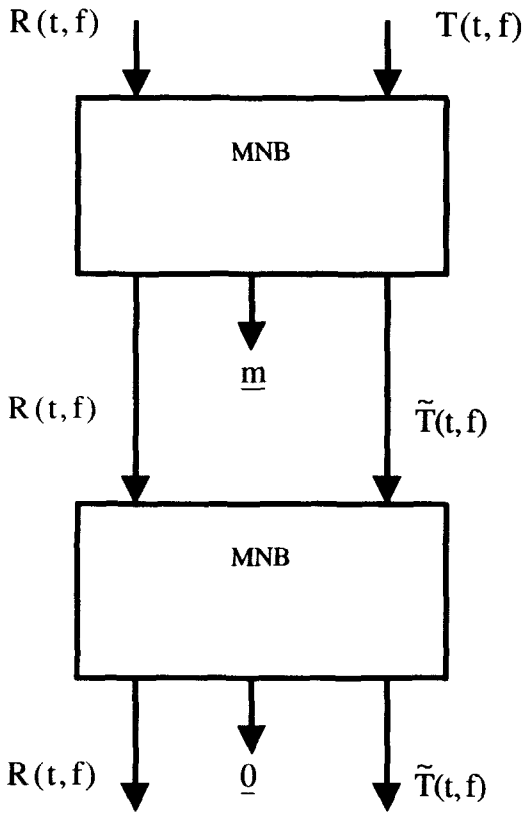

If $MNB(R(t,f), T(t,f)) = (R(t,f), \tilde{T}(t,f), \underline{m})$,

then $MNB(R(t,f), \tilde{T}(t,f)) = (R(t,f), \tilde{T}(t,f), \underline{0})$.

Figure 3. MNBs are Idempotent.

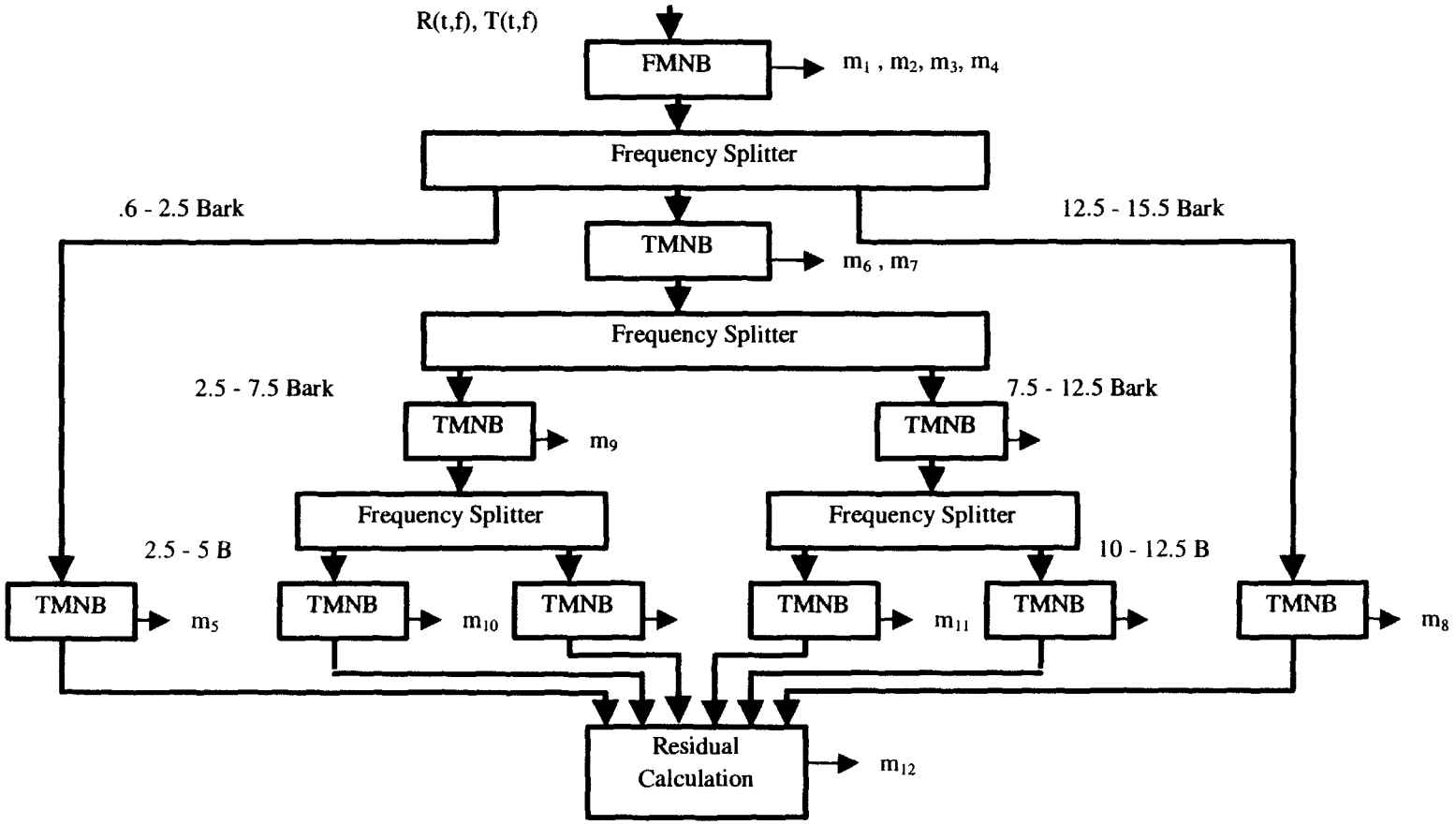

Figure 4. MNB Hierarchical Structure.

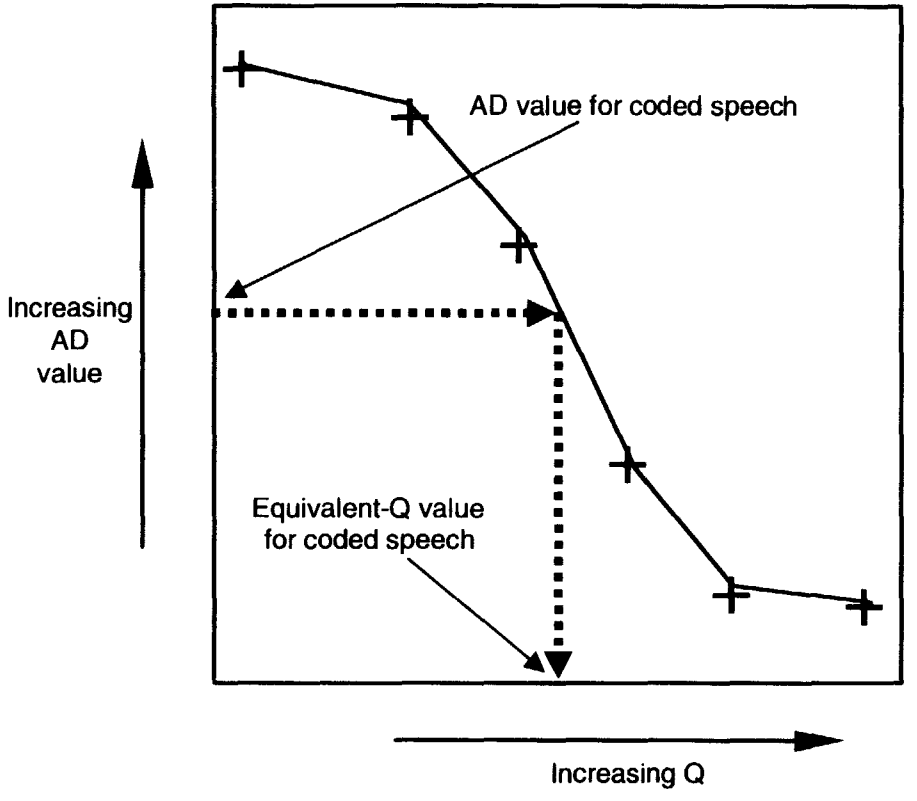

Figure 5. Determination of equivalent-Q value of coded speech.

T1E1.2/98-007R2

ANSI®
T1.403.ISDN–199X
Revision of
ANSI T1.408-1990

Draft American National Standard
for Telecommunications –

Network and Customer Installation Interfaces - Integrated Services Digital Network (ISDN) Primary Rate Layer 1 Metallic Interface Specification

Secretariat

Alliance for Telecommunications Industry Solutions

Approved Month __, 199X

American National Standards Institute, Inc.

Abstract

This standard provides the requirements for ISDN primary rate metallic interface specification for a network and customer installation (CI), and for interfaces between different items of customer premises equipment (CPE). The DS1 physical layer for the primary rate is specified in American National Standard for Telecommunications - Network and Customer Installation Interfaces - DS1 Metallic Interface, ANSI T1.403-199X. Requirements include electrical characteristics, format parameters and physical characteristics. This standard provides interface compatibility information and is not meant to be an equipment specification.

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Published by

American National Standards Institute
1430 Broadway, New York, New York 10018

Printed in the United States of America

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Foreword (This Foreword is not part of American National Standard ANSI T1.403.ISDN-199X)

This American National Standard is one of a series of network-to-customer installation interface standards developed by Technical Subcommittee T1E1 of Accredited Standards Committee T1, Telecommunications. Committee T1 standards serve the public through improved understanding between carriers, end-users, and manufacturers.

This standard is one of a set of standards which are applications utilizing the DS1 common criteria as specified in ANSI T1.403. Documents included in the ANSI T1.403 series (at the time that this document was approved) are listed below.

ANSI T1.403-199x - Customer Installation and Network - DS1 Metallic Interface

ANSI T1.403.ROB -Customer Installation and Network - Metallic Interface - Robbed-Bit Signaling State Definitions

This American National Standard for the layer 1 characteristics of the ISDN primary rate interface applicable at reference points S, T and U (as defined in American National Standard ANSI T1.217 for the ISDN primary rate access) was initiated by request for contributions to the American Standards Committee T1, Telecommunications, which is sponsored by the Alliance for Telecommunications Industry Solutions.

The electrical specification of this interface standard is based primarily on the American National Standard for Telecommunications — Network-to-customer installation, DS1 metallic interface (DS1 standard), ANSI T1.403-19xx. Additional provisions are based on ITU-T Recommendation I.431. The electrical specifications herein are intended to ensure that the signals delivered at the network interface from the user's equipment conform to the pertinent provisions of the DS1 standard and that the user's equipment will function (with respect to layer 1) properly with the received signals permitted by the DS1 standard at the network interface. They are also intended to ensure that equipment with interfaces conforming to the requirements of this standard will function (with respect to layer 1) properly when interconnected with interface cables having the prescribed characteristics.

Where the network access supports a ISDN primary rate, this standard is intended to assure compatibility at the network interface (NI). However, compliance with this standard does not guarantee such compatibility at all network interfaces. In some cases, location-oriented options are required to ensure compatibility at the network interface. This requirement for options is the result of significant differences among carriers and network elements. It should also be noted that transmission performance is a network service parameter and assurance of satisfactory performance is beyond the scope of this standard.

ANSI guidelines specify two categories of requirements: mandatory and recommended. The mandatory requirements are designated by the word "shall" and the recommendations by the word "should". Mandatory requirements generally apply to signaling and compatibility by specifying absolute, acceptable limits in those areas; recommendations generally refer to optional features.

There are two annexes in this standard. Both are informative and are not considered part of this standard.

Suggestions for the improvement of this standard will be welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, Suite 500, 1200 G St. NW, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Telecommunications, ANSI T1. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the T1 Committee had the following members:

xx, Chairman

xx, Vice-Chairman

xx, Secretary

EXCHANGE CARRIERS

Organization Represented Name of Representative

INTEREXCHANGE CARRIERS

MANUFACTURERS

GENERAL INTEREST

Technical Subcommittee T1E1 on Carrier-to-Customer Premises Equipment Interfaces, which is responsible for the development of this standard, had the following members:

Townsend, Rick, Chairman

Wright, Maynard, Vice-Chairman, Secretary

Goodson, William, Editor

Allred, Lorin
Baker, Leroy
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Ramsayer, Doug
Sacco, Charlie
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Symons, Erv
Tennyson, Gary
Tracey, Bob
van Gelder, Dick
Weadon, Richard
Welborn, Robert
Wessling, Tom
Worne, Bernard
Younge, Mark
Zimmerman, Brian

Network and Customer Installation Interfaces - Integrated Services Digital Network (ISDN) Primary Rate Layer 1 Metallic Interface Specification

1. Scope

1.1 General

This standard establishes performance and technical criteria for interfacing and interconnecting the various functional groups shown in Figure 1. Compliance with this standard is intended to ensure compatibility at the interface points I_a and I_b (Figure 1) and should not be construed as a constraint on the internal operation of the Network Terminations (NT), or Terminal Equipment (TE). The previous version of this standard accommodated equipment conforming to digital signal cross-connect level 1 (DSX-1) requirements at the S and T reference points. Such equipment will not meet the requirements of this standard.

> Note - The user's attention is called to the possibility that compliance with this standard may require use of inventions covered by the patent rights. By publication of this standard, no position has been taken with the respect to the validity of this claim or any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

The provisions of this standard are intended to be consistent with applicable requirements concerning safety and environmental conditions. Customer installation (CI) equipment shall be subject to the applicable safety requirements, and the rules of the Federal Communications Commission.

This standard is an application utilizing the DS1 common criteria as specified in ANSI T1.403. The DS1 standard contains specifications at the network interface (NI) for services at the digital signal level 1 (DS1) rate.

This primary rate access (PRA) standard defines specifications at physical interface points I_a and I_b (as shown in Figure 1). Criteria covered herein include Integrated Services Digital Network (ISDN) channel allocations, framing format, line code requirements, electrical characteristics, physical requirements, maintenance provisions, and other necessary criteria for:

- compliance with the electrical specifications at the NI as covered in clause 5 of the DS1 standard, ANSI T1.403. It is important that the electrical specifications applicable to I_a allow for a cable loss of up to 5.5 dB at 772 kHz between I_a and the NI, when the associated equipment is connected to a public network;
- the proper interfacing of interconnected CI equipment.

1.2 Structure

Most requirements in this standard apply equally to I_a and I_b. For these requirements, there is no reference to an interface point and it is to be understood that the requirements apply at both points. For other requirements and provisions, the application is explicitly stated. Requirements applicable at I_a and I_b imply requirements on the interface cable as stated in clause 10.

2. Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI T1.101-1994, *Synchronization interface standard for digital networks*[1]

ANSI T1.105-1995, *Digital hierarchy – Optical interface rates and formats specification*[1]

ANSI T1.107-1995, *Digital hierarchy – Format specification*[1]

ANSI T1.217-1991, *ISDN management – Primary rate physical layer*[1]

ANSI T1.403-1995, *Network to customer installation – DS1 metallic interface*[1]

ANSI/EIA/TIA-547-1989, *Network channel terminal equipment for DS1 service*[1]

ANSI/TIA/EIA-568 A-1995, *Commercial building telecommunications cabling standards*[1]

ITU-T Recommendation I.411 (3/93), *ISDN user-network interfaces – Reference configurations*[1]

ITU-T Recommendation I.431 (3/93) plus Amendment 1-1997, *Primary rate user-network interface– Layer 1 specification*[1]

ITU-T Recommendation Q.921 (3/93),, *ISDN user-network interface data link layer specification*[1]

UL 1459 -1995, *Standard for telephone equipment, 3rd edition*[2]

UL 1950 -1995, *Information technology including electrical business equipment, 3rd edition*[2]

ISO/IEC 8877: 1992, Information technology -- Telecommunications and information exchange between systems -- Interface connector and contact assignments for ISDN Basic Access Interface located at reference points S and T [1]

3. Definitions and acronyms

3.1 Definitions

3.1.1 access channel: A designated part of the information transfer capability having specified characteristics, provided at the user-to-network interface.

3.1.2 B-channel: A 64-kbit/s channel that carries customer information such as voice-calls, circuit-switched data, or packet-switched data. A distinguishing characteristic is that a B-channel does not carry signaling information for control of circuit-switching by the ISDN.

3.1.3 D-channel: A channel that is primarily intended to carry ISDN signaling information. As an option, it may carry packet-switched data, telemetry information, or both. For the primary rate interface, the D-channel bit rate is 64 kbit/s.

3.1.4 DS0 time slot: When the 192 digit time slots of a DS1 are "channelized" into 24, 8-digit time slots, each 8-digit time slot is referred to as a DS0 time slot.

3.1.5 embedded operation channel (EOC): An embedded operation channel (EOC) is provided on telecommunications facilities to support administration and maintenance. For primary rate access, the EOC is the ESF data link.

3.1.6 ESF terminal: The source or sink of ESF framing, CRC-6, and Performance Report Messages (PRM). This may be in NT2 or TE functional groups, or in equipment located within the network.

3.1.7 functional groups: Sets of capabilities in ISDN (e.g., NT1, NT2, TE, and TA per ITU-T Rec. I.411) that may be defined or distributed among ISDN equipment. These sets of

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[1] Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

[2] Available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, Telephone: 303-397-7956 (outside the U.S.), 800-854-7179 (U.S. and Canada), Fax: 303-397-2740, World Wide Web: http://global.ihs.com, E-mail: global@ihs.com

capabilities generally are defined at a high level. For example, the NT1 functional group has only layer 1 capability, while the NT2 may have both layer 1 and higher-layer capabilities.

3.1.8 H0-channel: A 384-kbit/s channel that is intended to carry customer information, such as high-speed data, video, and packet-switched data. The H0-channel does not carry ISDN signaling information.

3.1.9 H10-channel: A 1472-kbit/s channel that is intended to carry customer information, such as high-speed data, video, and packet-switched data. The H10-channel does not carry ISDN signaling information. The D-channel associated with the H10-channel carries the signaling information.

3.1.10 H11-channel: A 1536-kbit/s channel that is intended to carry customer information, such as high-speed data, video and packet-switched data. The H11-channel does not carry ISDN signaling information.

3.1.11 I_a: The 4-wire (2-pair) bi-directional PRA interface point on the network side of the termination equipment (i.e., NT1, NT2, TA, and TE), including the equipment connecting cord or equivalent on the user side of the interface cable.

3.1.12 I_b: The 4-wire (2-pair) bi-directional PRA interface point on the user side of the termination equipment (i.e., NT1 and NT2), including the equipment connecting cord or equivalent on the network side of the interface cable.

3.1.13 integrated services digital network (ISDN): A network – in general, evolving from an existing telephony network – that provides end-to-end digital connectivity to support a wide range of both voice and non-voice services. User access to an ISDN is provided through a limited set of standard multi-purpose interfaces.

3.1.14 network channel-terminating equipment (NCTE): A device that connects to the network on one interface and to terminal equipment on another interface.

3.1.15 NT1: A functional group that provides physical layer functionality for access line termination; e.g., a CSU has NT1 functionality.

3.1.16 NT2: A functional group that provides protocols above layer 1 and for DS1 path termination; e.g., a PBX has NT2 functionality.

3.1.17 performance report messages (PRM): An autonomous report, initiated by an ISDN PRA terminal (TE or NT/TE), providing a quantification of the quality of transmission incoming to the terminal. PRMs are initiated once per second.

3.1.18 phase transient: An event that causes movement of the phase of the signal with respect to absolute time (e.g., clock-rearrangement or pointer-quantization of wander).

3.1.19 physical interface: An interface at the layer 1 level of the OSI reference model.

3.1.20 primary rate access: A term used to describe a DS1 rate access supporting standard combinations of channels on a 1.536-Mbit/s payload.

3.1.21 receiver: The sink or terminator of any signal on a transmission medium.

3.1.22 receive signal: The signal received across an interface I_a or I_b by the associated equipment.

3.1.23 reference point: A conceptual point at the conjunction of two non-overlapping functional groups. In a specific access arrangement, a reference point may correspond to a physical interface between pieces of equipment, or there may not be any physical interface corresponding to the reference point. There may be more than one physical interface associated with a reference point.

3.1.24 regenerator: Equipment that reconstructs and retransmits a received pulse train.

3.1.25 remote alarm indication (RAI): A signal transmitted in the outgoing direction when a terminal determines that it has lost the incoming signal. RAI is commonly called the Yellow Alarm signal.

3.1.26 transmitter: The source or generator of any signal on a transmission medium.

3.1.27 transmit signal: The signal sent across an interface I_a or I_b from the associated equipment.

3.1.28 T1 line: A full-duplex digital transmission facility that is composed of two twisted metallic pairs and regenerators that carry one DS1 signal.

3.2 Acronyms

AIS	alarm indication signal
B8ZS	bipolar eight zero substitution
CI	customer installation
CCITT	International Telegraph and Telephone Consultative Committee
CSU	customer service unit
CRC	cyclic redundancy check
DL	data link
DS1	digital signal level 1
EOC	embedded operations channel
ESF	extended superframe format
FS	functional subset
ID	intermediate device
ISDN	integrated services digital network
ITU-T	International Telecommunication Union - Telecommunications Standardization Sector
NCTE	network channel terminating equipment
NI	network interface
NT	network termination
PBX	private branch exchange
PM	performance monitor
PRA	primary rate access
PRM	performance report message
PSD	power spectral density
PT	path termination
RAI	remote alarm indication
TE	terminal equipment
UI	unit interval
USOC	universal service order code

4. General information

This standard provides equipment interface compatibility requirements. The equipment interface information in this standard complements the DS1 specification (T1.403). Tariffs, contracts, or regulatory acts in various jurisdictions may contain more stringent requirements than those in this standard. Codeword and bit assignments, including those designated as reserved, shall be changed only by the formulating committee of this standard.

5. Electrical specifications

5.1 General

These electrical specifications describe the signals delivered across the reference points, S, T, and U, at interface points I_a and I_b, in both directions (see Figure 1). These are consistent with specifications for signals at the NI defined in the DS1 standard.

5.2 Terminating impedance

5.2.1 Receiver impedance and return loss

The nominal terminating impedance at the interface shall be 100 ohms. The return loss with respect to 100 ohms, over the frequency band from 100 kHz to 1 MHz, shall be at least 26 dB.

5.2.2 Longitudinal balance

The longitudinal balance of the impedance to ground of both transmitters and receivers shall be greater than 35 dB over the frequency range of 50 kHz to 1544 kHz when measured with an applied longitudinal voltage having a source impedance of 500 ohms and when terminated (metallic) in 100 ohms.

5.3 Transmission rates and synchronization

The following signal specifications describe characteristics for all signals at the interface. Differences between the receive and transmit signals are identified below.

5.3.1 Transmission rate and synchronization

The following is a provisional specification of transmission rate and synchronization that is the subject of continuing study.

5.3.1.1 Network connection characteristics

The network shall deliver a signal synchronized from a clock having an accuracy of 1×10^{-11} (stratum 1). When synchronization by a stratum 1 clock has been interrupted, the signal delivered by the network to the interface shall have a minimum accuracy of 4.6×10^{-6} (stratum 3e).

While in normal operation, the customer installation shall transmit a 1.544-Mbit/s signal having a bit rate accuracy equal to that of the received signal by either of the following methods:

- locking the frequency of its transmitted signal clock to the long-term average of the incoming 1.544-Mbit/s signal. (This is often referred to as "loop timing".)
- providing equal signal bit rate accuracy from another source.[3] While in any maintenance states controlled by signals or messages passed over the data link, all TE, NT2, and NT1 equipment shall operate with received signals having bit rate stability of ± 32 ppm(stratum 4).

5.3.1.2 Requirements at I_a/ I_b

The following requirements are specified in terms of the tolerance to received signal variations at interface I_a and the limitation on the transmitted signal at I_a from the associated equipment. Each receiver requirement implies a requirement on the transmitted signal at the interface I_b of the connected equipment or the network, as applicable. Similarly, each transmitter requirement implies a receiver requirement at the interface I_b of the connected equipment or network, as applicable. Requirements that are unique to a particular functional grouping, e.g., NT2, are specifically noted.

Equipment entities designed to operate under the conditions covered by more than one of the following subclauses shall comply with the requirements in all of the relevant subclauses.

5.3.1.2.1 Terminating equipment synchronized to a network clock

Receiver and transmitter requirements are listed below

- *Receiver requirements:* Receivers of signals across interface I_a shall be capable of receiving signals which comply with stratum 3e requirements of ANSI T1.101 (1.544 Mbit/s +/- 4.6 ppm). However, operation with a received signal transmission rate in the range of 1.544 Mbit/s ± 32 ppm is required in any maintenance states controlled by signal or messages passed over the data link (see clause 8). Receivers operating in equipment with stratum 3e clocks may report frame slips in the maintenance state. This depends on the synchronization policy used in the receiving equipment.

---

[3] Synchronization to an independent source may result in serious degradation where the source is not traceable to a Stratum 1 clock.

NOTE – In normal operation, the bit stream is synchronized to stratum 1 primary reference and the long-term bit rate accuracy is 10^{-11}, but the full bit range of ± 4.6 ppm should be expected in abnormal conditions.

- *Transmitter requirements:* The average transmission rate of signals transmitted across I_a by the associated equipment shall be the same as the average transmission rate of the received bit stream. The need for a requirement applicable to TEs only, which would require a tighter coupling of the phase/bit rate of the transmitted bit stream to the received bit stream, is subject to further study.

NOTE – Where multiple network interfaces are involved, the transmission rate of the transmitted signal is normally determined by the signals received across only one interface, but the transmission rates of all interfaces are normally synchronized to the same master source.

5.3.1.2.2 TE operating behind an NT2 that is not synchronized to a network clock

Receiver and transmitter requirements are listed below

- *Receiver requirements:* Receiver of signals across interface I_a shall be capable of receiving signals having bit rates of 1.544 Mbit/s ± 32 ppm.
- *Transmitter requirements:* The transmitted signal across I_a shall be synchronized to the received bit stream. The required coupling (relative phase) of the transmitted and received bit streams is subject to further study.

5.3.1.2.3 Receive bit stream synchronized to customer-provided transmitted signal clock (leased line application)

Receiver and transmitter requirements are listed below

- *Transmitter requirements:* The transmission rate of the signals transmitted across interface I_a (or I_b) shall be in the range of 1.544 Mbit/s ± 32 ppm. Requirements, if any, on the necessary synchronization of transmitted and received bit streams is beyond the scope of this standard.
- *Receiver requirements:* The tolerance of receivers to variations in the transmission rate of signals received across I_a (or I_b) is application-dependent upon the far-end transmitter tolerance.

5.4 Transmitter and receiver transmission requirements

5.4.1 Line code

The line code shall be B8ZS.

5.4.2 Standard pulse characteristics

The following characteristics of the standard pulse form part of the specification for signals transmitted and received at I_a and I_b. The signals at I_a and I_b are specified in 5.5.

Specifications at I_a and I_b shall be the same as for the CI reference signal in ANSI T1.403 for the following items:

- Test termination
- Test frequency
- Transmission rate
- Pulse shape
- Pulse imbalance
- 60-Hz variations - This applies only at the I_a associated with the NT1.

Specifications at I_a and I_b are given in ANSI T1.403 for the CI for the following items:

- Jitter

- Wander
- Phase transients

5.5 Transmitter and receiver requirements

5.5.1 Transmitter requirements

At I_a and I_b, transmitted pulses shall meet the requirements of the CI reference signal, as defined in ANSI T1.403.

5.5.2 Receiver requirements

Receivers shall receive input data sequences under the interference test conditions as specified in 5.5.2.2 and with signals having the following characteristics:

- transmission rates over the acceptable range specified in 5.3.1,
- pulse imbalance over the acceptable range specified in ANSI T1.403, and
- superimposed jitter and wander over the acceptable range specified in ANSI T1.403.

In demonstrating compliance with this requirement, it shall be sufficient to demonstrate reception of data sequences with a bit error ratio of less than 10^{-7}.

5.5.2.1 Received signal characteristics

Signals delivered to receivers shall be a network reference signal as defined in ANSI T1.403, that has traversed a length of cable. The length of cable shall have an attenuation in the range of 0.0 to 22.0 dB, at 772 kHz, between 100-ohm terminations.

5.5.2.2 Interference test conditions

The following test conditions shall be used in determining compliance with the requirements of 5.5.2.

- interference described in the following (a) and (c) superimposed simultaneously;
- interference described in the following (b) and (c) superimposed simultaneously.

In both cases, the 60-Hz variation is limited to ± 10 %.

a) *Gaussian interference:* Noise having a Gaussian amplitude distribution and a power spectral density (PSD) flat over the frequency range of 100 kHz to 1544 kHz and rolling off a 6 dB per octave (1544-kHz cut-off) to 3 MHz, and having a power, measured into 100 ohms, in the frequency band of 400 kHz to 1350 kHz[4] of –32.7 dBm. The variation, relative to the specified spectrum, in the amplitude of the noise at each frequency shall not exceed 1 dB. The amplitude distribution of the noise shall conform to the Gaussian distribution up to a Peak-to-RMS ratio of at least 14.5 dB;

b) *Single frequency:* A sinusoidal signal at 772 kHz having a power, measured into 100 ohms, of –20 dBm;

c) *60-Hz power-related interference:* Noise simulating power line induction (60-Hz and associated harmonics) shall be superimposed on the received signal. The noise shall consist of any two of the harmonics listed in the following table at the power level indicated.

60 Hz Power interference noise

[4] The choice of 400 kHz and 1350 kHz is arbitrary, but note that the two frequencies determine points on the PRA Near End Cross Talk (NEXT) PSD at the same value, –95.6 dBm/Hz, and integration of the PRA NEXT PSD over this range includes essentially all of the first lobe power (–30.6 dBm).

Frequency (Hz)	Power (dBm into 100 ohms)
60	–49.5
180	–51.5
300	–61.5
420	–67.5
540	–72.5
660	–76.5

5.6 Powering arrangements

5.6.1 Transmit and receive pair

Equipment associated with interface I_a or I_b shall not apply power (except signal power) to the transmit or receive pair in the metallic or longitudinal mode.

5.6.2 Powering across an interface

The use of a third pair and contacts 7 and 8 for powering within the CI across an interface (e.g., powering an NT1 from an NT2 or TE) is optional (see Table 1). Power shall not be delivered to the NI by either the CI or the network.

6. Framing formats

Both transmit and receive signals shall be framed in the extended superframe (ESF) format as specified in ANSI T1.403.

7. ISDN PRA channel structure

A ISDN PRA channel[5] occupies an integral number of DS0 time slots and the same DS0 time slot positions in every frame.[6] The number of DS0 time slots required for each ISDN channel type is defined in Table 2 - ISDN channels.

For channelization arrangements consisting of 4 H0-channels or 1 H11-channel, signaling, if required, is carried on another interface structure within the same user-to-network access arrangement.

7.1 D-channel

DS0 Time slot 24 shall be assigned to the D-channel when used. Contiguous HDLC flags shall be transmitted on the D-channel when its layer 2 has no frames to send.

7.2 B-channel and H-channels[7]

Within each B or H channel, the logic content of the available bandwidth shall be unconstrained, except as noted in clause 7.

B and H channels shall be assigned as follows:

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[5] This definition for a "channel" differs from the one given in ANSI T1.403.

[6] PCM analog signals sent over a bearer channel are transmitted most-significant-bit-first. If data is transported in HDLC frames, the least-significant bit of each byte is transmitted first, with the exception of the CRC, for which the most-significant bit is transmitted first.

[7] For an interim period, a fixed-time -slot allocation to form channels may be required; e.g., see ITU-T Rec. I.431, annex A.

- a B-channel may be assigned to any DS0 time slot in the frame
- an H0-channel may be assigned any six DS0 time slots in the frame. The DS0 time slots shall be in ascending numerical order but not necessarily consecutive.
- H10-channel shall be assigned to any consecutive 23 DS0 time slots in the frame
- an H11-channel shall be assigned to DS0 time slots 1 through 24 in a frame.

The DS0 time slots associated with a channel may vary on a call-by-call basis. Mechanisms for the assignment of these DS0 time slots are specified in ITU-T Rec. Q.931.

When a D-channel is assigned to DS0 time slot 24 of an individual PRA, only 23 DS0 time slots are available for assignment. This arrangement precludes assignment of an H11- channel to this PRA, since only 23 DS0 time slots are available for B- and H-channel assignment. The H11-channel can be assigned to a PRA that is not supporting the D-channel in its 24th DS0 time slot.

Codes for idle DS0 channels consist of patterns including at least 3 binary ones in an octet shall be transmitted on every DS0 time slot that is not assigned to a channel (e.g., DS0 time slots awaiting channel assignment on a per-call basis, residual DS0 time slots on an interface that is not fully provisioned, etc.) and on every DS0 time slot of a channel that is not allocated to a call in both directions.

8. Maintenance

General maintenance functions shall be provided as described in ANSI T1.403.

ISDN PRA Loopback functions are described below.

8.1 Loopbacks

Loopbacks are used by network providers and users as operations and maintenance tools to aid in problem resolution. The loopbacks discussed in this section shall be controlled by ESF data-link messages as specified in ANSI T1.403.

The line loopback associated with l_a shall be provided. All other loopbacks are considered optional. For additional information on the loopbacks discussed in this clause, see ANSI T1.403.

The loopback types are described in the following subclauses and their arrangements illustrated inFigure 2. *la* loopback commands originate from the network side of the *la* and the looped signal is returned back toward the network side. *lb* loopback commands originate from the TE side of the *lb* and the looped signal is returned back toward the TE side.

8.1.1 Line loopbacks

Line loopbacks are defined at l_a and l_b and shall operate as specified in ANSI T1.403.

- *Line loopback la*: This is controlled by *la* loopback codes specified in ANSI T1.403. (When this loopback is in equipment that realizes the NT1 functional group, it is referred to in ITU Rec. I.604 as loopback 2.)
- *TE Line loopback la (optional)*: This is activated by the TE line loopback code specified in ANSI T1.403. (When this loopback is in equipment that realizes the TE functional group, it is referred to in ITU Rec. I.604 as loopback 3.) It should be noted that if this loopback is implemented, it is electrically the same as the *la* line loopback. That is, both the line loopback activate and the TE line loopback active codes activate the same loopback. This loopback is deactivated by the same code as for line loopback *la*.
- *Line loopback lb (optional):* This is controlled by *lb* loopback codes specified in ANSI T1.403. (When this loopback is in equipment that realizes the NT1 functional group, it is referred to in ITU Rec. I.602 as loopback C.)

An AIS signal shall be sent forward as a replacement for the looped signal whenever a line loopback is activated. See Figure 3.

8.1.2 Payload loopback

A payload loopback is a characteristic of the primary rate path termination and shall operate as specified in ANSI T1.403. Path terminations occur in equipment that implements NT2, TE, and TA functionality. They do not occur in equipment that implements only NT1 functionality - see ANSI T1.217. These loopbacks may face either the user or network, depending upon the path that is terminated.

9. Environmental conditions and protection

9.1 Isolation from external voltages

Precautions shall be taken to ensure that no fire or shock hazard is created by TEs, NTs or interface cabling under power fault conditions. Test conditions described in Underwriters Laboratories standards on information systems, business equipment and telephone equipment shall apply. See also ANSI T1.403.

9.2 Electrical environment

A detailed specification of the electrical environment, relative to the specified interfaces, is beyond the scope of this standard. However, interfaces I_a of equipment shall be compatible with (i.e., not be damaged by stresses that are characteristics of outside plant cable) exposed wiring. Interfaces I_b of equipment may be designed to be compatible with unexposed wiring only. Descriptions of exposed and unexposed wiring may be found in ANSI/NFPA 78 and in ANSI/NFPA 70. Specific requirements and references related to exposed and unexposed wiring may be found in ANSI T1.403.

10. Physical characteristics

10.1 Interface cable requirements

The characteristic impedance of cable pairs shall be in the range of 70 to 130 ohms at 772 kHz. All new installations should use Category 3 (or better) cable as defined in ANSI/TIA/EIA-568-A. It might appear that the worst-case cross-talk loss (multiple disturber loss) of the cable that is acceptable is defined by the transmit level (see 5.5.1) in combination with the specified noise conditions under which satisfactory receiver operation is required. However, a higher cross-talk loss should be assured to provide margin, particularly in cabling used to connect equipment to the NI.

10.1.1 Between CI equipment (NT1, NT2 and TE)

Interface cables (or cabling) shall include two twisted metallic pairs. (They will frequently be part of a customer-premises distribution system.) The insertion loss of each pair at 772 kHz (measured between 100 ohm terminations) shall be less than 22 dB (see Figure 1). For Category 3 cable, the length is limited to about 3000 feet (913 m).

10.1.2 Between NT1 and NI

The cable between the NT1 and the NI shall be limited in length such that the insertion loss at 772 kHz (measured between 100-ohm terminations) is less than 5.5 dB (see Figure 1), except when mutually agreed between the network provider and user.

NOTE – The length limitation of interface cables can be overcome by the use of repeaters.

10.2 Wiring polarity integrity

The terminating equipment receivers shall not be dependent on a specific polarity for pairs of the interface cable. Wires in each pair may be reversed.

10.3 Connector

10.3.1 CI equipment

Where a connector is used at interface point I_a or I_b, the connector shall be a miniature 8-position non-keyed plug and jack. The equipment side (connecting cord) shall terminate in a plug and the

interface cable (or cabling) shall terminate in a jack. The connecting cord is a part of the equipment but may be detachable and provided as a separate part. When the connecting cord is detachable, it shall have a plug on one end so that the connector at I_a or I_b is a plug to mate with the jack of the interface cable. The plug and jack illustrated in Figure 4 shall conform, except for contact assignments, to the specification in ISO 8877. Contact assignments shall be as specified in Table 1.If shielded cable is used for the interconnection, shield continuity may be provided by using contacts as indicated in Table 1 or by using a special arrangement providing shield continuity.

When an NT or TE is connected to the NI with a separate interface cable, the cable shall have a jack at interface I_a and a plug for connecting at the NI. When the I_a of the NT or TE is directly connected to the NI, the associated connecting cord shall have a plug for connecting to the NI.

10.3.2 NI

The interconnection at the NI shall be via one of the Universal Service Order Codes (USOC) connectors referenced in ANSI T1.403, which includes single and multiple interface connectors.

11. Environmental conditions and protection

11.1 Isolation from external voltages

Precautions shall be taken to ensure that no fire or shock hazard is created by TEs, NTs or interface cabling under power fault conditions. Test conditions described in Underwriters Laboratories standards UL 1459 and UL 1950 shall apply. See also Annex A.

11.2 Electrical environment

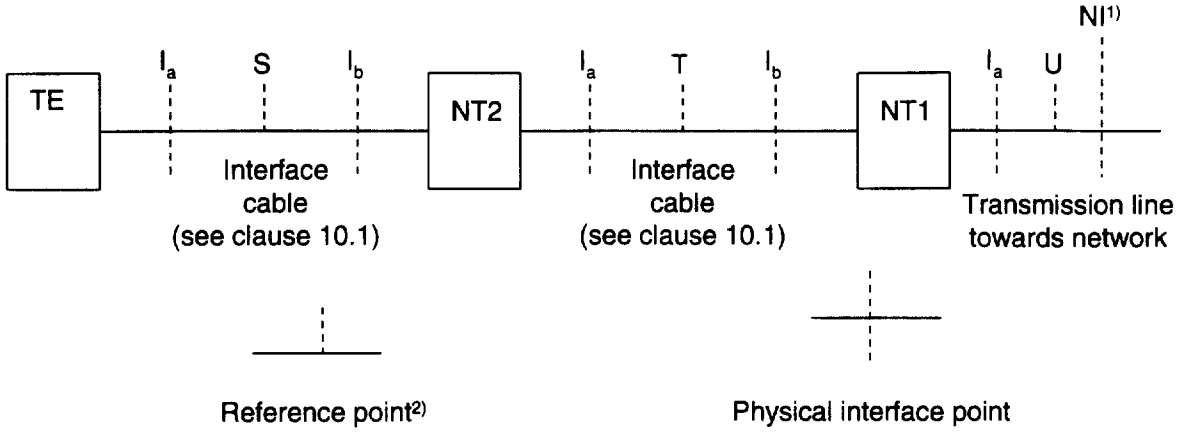
A detailed specification of the electrical environment, relative to the specified interfaces, is beyond the scope of this standard. However, interfaces I_a of equipment shall be compatible with (i.e., not be damaged by stresses that are characteristics of outside plant cable) exposed wiring. Interfaces I_b of equipment may be designed to be compatible with unexposed wiring only. Descriptions of exposed and unexposed wiring may be found in ANSI/NFPA 78 and in ANSI/NFPA 70. Specific requirements and references related to exposed and unexposed wiring may be found in Annex A.

Table 1 - Contact assignments for 8-position plug and jack

Contact number	Function		Notes
1	Receive	Transmit	
2	Receive	Transmit	
3	Optional shield - 1/2	Optional shield - 1/2	No connection except when used for shield continuity
4	Transmit	Receive	
5	Transmit	Receive	
6	Optional shield - 4/5	Optional shield - 4/5	No connection except when used for shield continuity
7	No connection	No connection	Reserved for power (–)*
8	No connection	No connection	Reserved for power (+)*
* Optional			

Table 2 - ISDN channels

Channel	Number of DS0 time slots required	Bit rate (kbit/s)
D	1	64
B	1	64
H0	6	384
H10	23	1472
H11	24	1536



1) The NI may have no significance in private network applications
2) The physical locations of reference points are not significant

Figure 1 - ISDN primary rate functional reference configuration

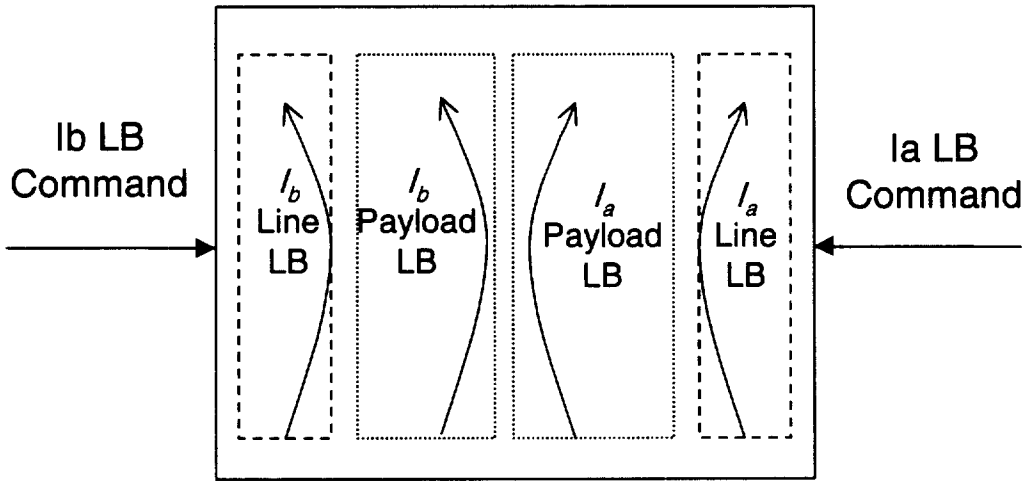
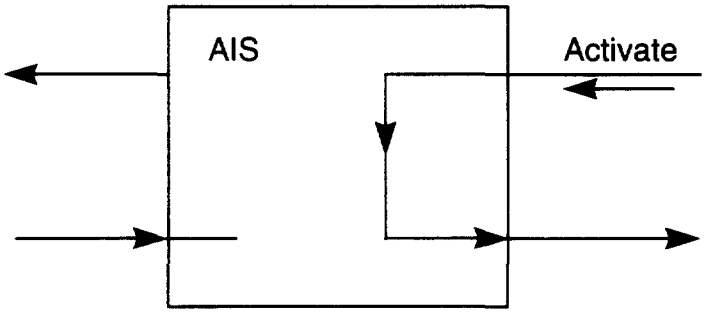
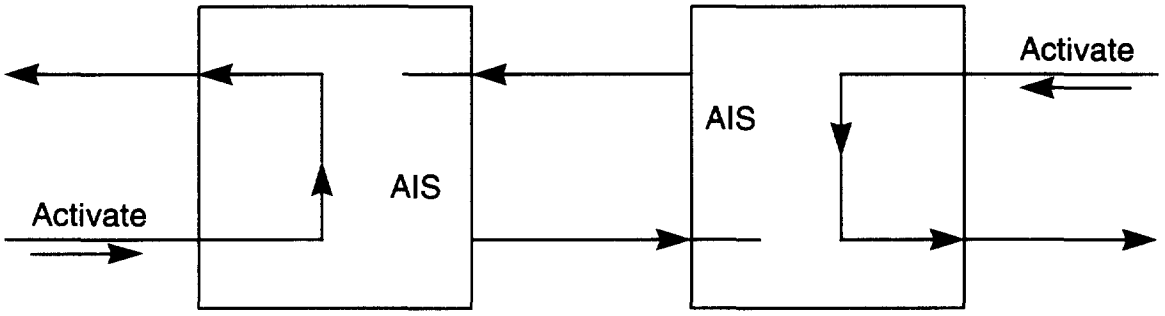


Figure 2 - Loopback arrangements

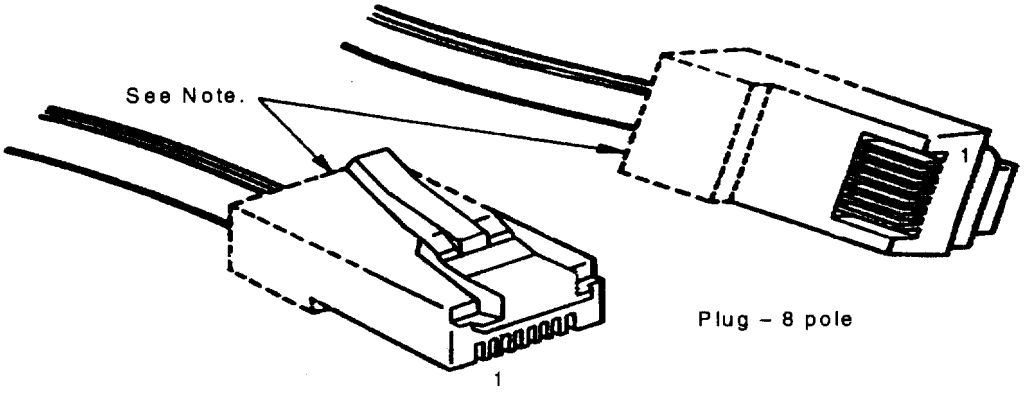


(a) Single-ended loopback configuration

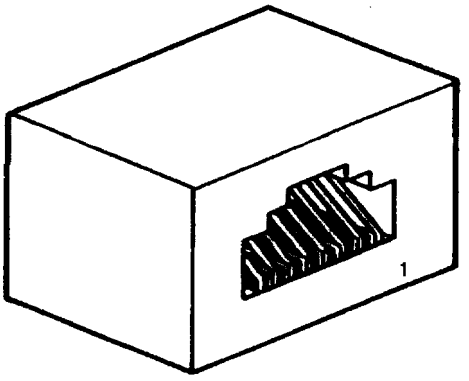


(b) Dual loopback configuration

Figure 3 - Line loopback



Note – This portion of the plug illustrates a structure necessary for securing the cordage and is not pertinent to proper mating with the jack.



NOTE – See ISO 8877 for dimensions

Figure 4 - 8 position non-keyed connector

Annex A
(informative)

Wiring recommendations and overvoltage, surge protection, and EMC reference information

A.1 Unexposed wiring

NTs having interfaces I_b intended to be connected only to interface cabling in the unexposed wiring category should not be damaged by the following conditions:

- DC voltages with the following characteristics:
- *Amplitude:* 56.6 V
- *Current limit:* 0.5 amperes
- *Duration:* continuous

To test for compliance, voltages of each polarity should be applied between each interface conductor and every other interface conductor and the ground reference of the equipment power source, where such power source is not associated with the interface. The application of each voltage should be maintained for 5 minutes.

- AC voltages with the following characteristics:
  - *Amplitude:* 200 V peak
  - *Source resistance:* 1500 ohms
  - *Frequency:* 20 Hz
  - *Duration:* 2 seconds on, 4 seconds off, continuously

To test for compliance, the voltage should be applied between each interface conductor and every other interface conductor and between each interface conductor and the ground reference of the equipment power source, if such power source is not associated with the interface. The application of each voltage should be maintained for 5 minutes.

- Voltage surges with the following characteristics:
  - *Amplitude:* 1000 V peak .
  - *Rise time:* 1 us
  - *Fall time:* 50 us
  - *Source impedance:* impedance of 0.008 μF capacitance in series with each lead to be tested.

To test for compliance, 10 surges of each polarity should be applied between all interface conductors and the ground reference of the equipment power source, where such source is not associated with the interface. Each surge should be coupled simultaneously to individual conductors, each through an impedance of 0.015 μF, balanced with respect to individual conductors of the circuit pair. For TEs that use interface power source 2 (see I.431), the surge should also be applied with respect to the reference of the power source.

A.2 Exposed wiring

Specific requirements related to exposed wiring are subjects for further study.

A.3 Overvoltage, surge protection, and EMC

The purpose of this interface standard is to present the electrical and physical characteristics of the ISDN primary rate interfaces at interface points I_a and I_b at reference points S, T and U. Such phenomena as lightning and overvoltage due to inductive interference or power crosses lie